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Chapter Fifteen
MAINTENANCE AND PROTECTION OF TRAFFIC THROUGH CONSTRUCTION ZONES

Traveling through a construction zone can be difficult and confusing to drivers. A well-planned traffic control design can alleviate many of these difficulties and confusions. Chapter Fifteen provides information for the road designer to develop a safe and well-conceived traffic control plan through construction zones including construction options, geometric design of crossovers and detours, and roadside safety through construction zones.

15.1 TRAFFIC MANAGEMENT

Highway construction will almost always disrupt normal traffic operations; therefore, MDT requires every project to address traffic control through construction zones. This may range in scope from very detailed plans to merely referencing the *MDT Detailed Drawings* and the *Manual on Uniform Traffic Control Devices (MUTCD)*. With much of the Department's highway program involved in upgrading existing highways, a well-conceived traffic control plan is essential. This will minimize the operational and safety problems through the construction zones.

15.1.1 Responsibilities

The Department requires a coordinated effort from various units to implement a successful traffic control plan through construction zones. The following discusses the responsibilities of these Department units:

1. Road Designer. The road designer is responsible for:

    a. determining the initial traffic control plan that will be used in the project (e.g., detours, crossovers, lane closures);

    b. providing at least one acceptable construction method that can be used on the project;

    c. developing the geometric design for specially constructed detours and crossovers;

    d. ensuring that a detailed review is given to the proposed traffic control plan during the plan-in-hand review; and

e. providing quantities for temporary pavement markings.

2. District Traffic/Construction. The District Traffic/Construction is responsible for:

   a. developing the detailed traffic control plan for the project;

   b. ensuring that the proper selection and placement of traffic control devices occurs (e.g., pavement markings, barricades, signing);

   c. addressing the roadside safety concerns through the construction zones (e.g., construction clear zones, portable concrete median barriers, placement of construction equipment and supplies);

   d. making provisions for informing the public through various media options of the necessary project information (e.g., proposed road closure); and

   e. providing quantities for traffic control devices.

3. Contract Plans Section. The Contract Plans Section is responsible for inserting into the project contract the necessary recurring special provisions relative to the maintenance and protection of traffic through construction zones.

15.1.2 Evaluations

The objective of the traffic control plan (TCP) is to provide a strategy that will efficiently and safely move traffic through or around the construction zone. To accomplish this strategy, evaluate the following when preparing a TCP:

1. Preliminary Review. Conduct a preliminary discussion of the TCP during the Preliminary Field Review. The discussion should include such items as methods of traffic control that will be feasible for the project, location of detours, duration of various construction aspects, etc. The road designer should involve the District Traffic and Construction personnel in the development of the TCP throughout the design of the project.

2. Engineering. Some of the engineering aspects to consider include:

   a. Highway Capacity. The TCP should provide adequate capacity to handle the expected traffic volumes through the construction zone or detour at an acceptable level of service. This may require converting shoulders to travel lanes, eliminating on-street parking, constructing temporary lanes, opening additional lanes during peak periods, or providing public transportation.

b. Geometrics. The TCP should have suitable geometry so that a driver can safely maneuver through the construction zone, day or night. Frequent and abrupt changes in geometrics, such as lane narrowing, lane drops or main road transitions that require rapid maneuvers, should be avoided. Section 15.3 presents geometric design criteria for construction zones.

c. Roadside Safety. Providing a safe environment both for the traveling public and construction workers is an essential element through construction zones. Traffic safety through construction zones should be an integral and high priority element of every project from planning through design and construction. Section 15.4 addresses roadside safety concerns through construction zones.

d. Overhead Lighting. If the existing roadway has overhead lighting, it must be maintained during construction.

3. <u>Constructability</u>. The road designer should evaluate the proposed construction sequence to determine if the project can be constructed based on the proposed TCP. Some of the elements the designer should evaluate include:

   a. whether or not traffic will be able to safely maneuver through all the proposed intermediate horizontal and vertical alignment steps,

   b. the location of adjacent traffic relative to worker and traffic safety,

   c. whether or not there is sufficient room for equipment maneuverability, and

   d. whether or not the construction phasing is appropriate.

4. <u>Construction</u>. There are several construction options available that will improve the TCP. These should be discussed during the design phase of the project. Some of these options include:

   a. the use of special materials (e.g., quick curing concretes that will allow traffic within hours of pouring);

   b. the use of special designs (e.g., using precast box culverts versus cast-in-place box culverts or bridges);

c. requiring special scheduling requirements which will reduce traffic disruptions (e.g., working at night near national parks);

d. developing project phasing plans which will allow traffic to use the facility prior to project completion; and

e. contractor cost incentives/disincentives for early/late completion of construction may be useful for projects having high ADT. Where there is FHWA oversight, these incentives must be justified and approved by the FHWA.

5. Operation Selection. The initial determination on whether the project will require a detour, lane closures, crossovers, temporary closures, etc. needs to be made during the Preliminary Field Review. Section 15.2 provides additional guidance for determining which of these various construction applications may be appropriate.

6. Business. In urban areas, coordinate the TCP with local businesses. At a minimum, access to at least one of any business' approach must be maintained at all times.

7. Pedestrians and Bicycles. Safe accommodation of pedestrians/bicyclists through the construction zone should be addressed early in project development. Situations that would normally warrant special pedestrian/bicyclist considerations may include locations where sidewalks traverse the construction zone, where a designated school route traverses the construction zone, where significant pedestrian/bicyclist activity or evidence of such activity exists and where existing land use generates pedestrian/bicyclist activity (e.g., parks, schools, shops).

Consider the following principles when addressing pedestrian accommodation through construction zones:

a. Physically separate pedestrians and vehicles from each other.

b. Ensure pedestrian walkways/bicycle paths are free of any obstructions and hazards (e.g., holes, debris, mud, construction equipment, stored materials).

c. Consider temporary lighting for all walkways that may be used at night, particularly if adjacent walkways are lighted.

d. Clearly delineate all hazards (e.g., ditches, trenches, excavations) near or adjacent to walkways.

e. Walkways under or adjacent to elevated work activities (e.g., bridges, retaining walls) may require covered walkways.

f. Where pedestrian walkways/bicycle paths can not be provided, then direct pedestrians/bicyclists to an alternative safe location (e.g., the other side of the street).

g. Stage construction operations so that, if there are two walkways, they both are not out of service at the same time.

h. Plan the construction so that any temporary removal of sidewalks in front of businesses, schools, etc., can occur in the shortest amount of time practical or be scheduled around non-peak pedestrian times (e.g., summer construction around schools).

i. All temporary sidewalks must meet the handicapped accessibility requirements for surface, curb ramps, sidewalk cross slopes, longitudinal slopes, etc. For more information on handicapped accessibility criteria, see Section 18.1.

15.2 CONSTRUCTION APPLICATIONS

The following sections present several construction applications that the designer should consider when developing the project phasing. The several variables that affect the needs of the construction zone include location of work, roadway type, speed, traffic volume, geometrics, vertical and horizontal alignment, pedestrians and intersections. The designer should realize that each construction zone is different and that not all applications will work on every project. For most projects, there may be more than one alternative. Typical applications should be altered to fit the conditions of the particular construction zone.

15.2.1 Work Beyond the Roadway

Traffic will generally not be impeded when the construction area is beyond the roadway (e.g., adding a second roadway to an existing 2-lane facility). The designer should ensure that there are enough access points available to the contractor to allow for construction equipment to exit, enter or cross the highway in a safe manner. Sufficient sight distance should be available to both the motorist and the equipment operator.

15.2.2 Shoulder Work and Partial Lane Closures

Shoulder work which does not encroach into the travel lane will generally have minimal impact on traffic if proper signing is provided to advise the motorist. All temporary traffic control signing and pavement markings must be in accordance with the *MUTCD*. Workers may require protection with the appropriate channelizing devices, portable concrete median barrier and/or a truck-mounted attenuator. Work spaces should be closed off by a taper or channelizing device with the appropriate length as provided in Section 15.3.4.

Partial lane closures may be appropriate where there are:

1. short construction durations;

2. minimal hazardous conditions (e.g., no dropoffs greater than 150 mm next to the roadway); and

3. minimal impacts to traffic.

Where partial lane closures are used, the remaining lane width should be 3.3 m. However, a 3.0 m lane width may be utilized with low-volume roadways that have low truck volumes. Full lane closures should be considered where there is a substantial volume of wider vehicles (e.g., trucks, buses, recreational vehicles) or where construction is adjacent to high-speed traffic. The following sections provide information for full lane closures.

15.2.3 Lane Closure (2-Lane Highways)

Lane closures on 2-lane highways will generally require shifting traffic to the shoulder or providing traffic for both directions on a 1-lane roadway. The designer should consider alternative treatments (e.g., detours) if the lane closure will be of a long duration, substantial length, and/or if the roadway has heavy traffic volumes.

Where detours are impractical, give consideration to reconstructing existing shoulders to allow them to be used as a temporary traffic lane. Proper signing and pavement markings are necessary to shift traffic to the appropriate locations. See Section 15.3.4.

For short distances and construction sites on low-volume roads, the use of alternating traffic on 1-lane roads may be acceptable. This strategy is commonly used with the reconstruction of low-volume bridges where each side is reconstructed in separate phases. Adequate sight distance and signing must be available at the site to ensure the motorist understands the appropriate action to take. For daily closures, flaggers may be used to control traffic through the site. For long-term closures, consider using temporary traffic signals to control traffic through the construction zone.

15.2.4 Single-Lane Closures (4-Lane Highways)

Single-lane closures on divided facilities should be discussed at the Plan-in-Hand. They may be appropriate if:

1. they will only cause minor delays during peak time periods, and

2. the construction will not result in a substantial increase in hazards to traffic and/or construction personnel.

In urban or other high-volume areas, give consideration to reconstructing and shifting traffic to the shoulder or reducing lane widths to maintain both lanes of traffic through the construction area. If narrower lanes are used, care should be given to ensure wide loads can still be accommodated (e.g., alternative routes are available). All lane shifts should meet the taper lengths presented in Section 15.3.4.

15.2.5 Two-Way Traffic on Divided Highways

15.2.5.1 Guidelines

The decision on when to use 2-way traffic on a single roadway of a divided highway will be made on a project-by-project basis. The decision should be made prior to the Scope of Work and preferably at the Preliminary Field Review. The input of Construction personnel is essential. In making this decision, consider the following factors:

1. Lane and Shoulder Widths. The minimum allowable lane and shoulder widths are dependent on the volume of traffic and the percentage of trucks. Use Figure 15.2A to determine the shoulder width of the single roadway.

DHV for 3.6 m Lane Widths	Shoulder Width
1000	1.2 m or greater
800	0.6 m
700	0

SHOULDER WIDTH CRITERIA

Figure 15.2A

2. Construction Efficiency. Separating the traffic from the construction activity will always result in increased construction efficiency. However, the increased efficiency may be minimal for activities that can be readily performed with stage construction (one lane at a time), such as cold milling or paving. Closure of a roadway on a divided highway provides the greatest advantage when the construction activity requires grading or an item that would result in temporary closure of one roadway, such as the replacement of a drainage structure.

3. Project Length. Closing a single roadway may result in a significant reduction in the operational efficiency of the remaining roadway. Traffic may back up behind slower vehicles if the two-way traffic is great enough and the segment of closure is greater than 6 km. The evaluation of these factors is covered in 15.2.5.2.

4. Width Restrictions. A single roadway should not restrict the width of vehicles because of reduced lane or shoulder widths. Where it is necessary to restrict the roadway width, the designer should coordinate with the Motor Carrier Services.

5. Alternative Detour Routes. This option is generally only practical if both roadways of a divided highway are closed at the same time. However, the designer should only consider this alternative if no other option is practical. The alternative route should be a facility equivalent to a single roadway of the divided highway.

6. Temporary Lanes in Flush Median. Providing temporary lanes is usually only practical where the traffic volumes would exceed the capacity of the single roadway. The length of temporary lanes should be kept to a minimum.

15.2.5.2 Design

The following provides several design considerations where 2-way traffic on a single roadway of a divided highway is used:

1. Length. Studies have found that the optimum segment length of 2-way traffic on divided highways is less than 6 km. Where segments exceed 6 to 8 km, operational efficiency is often reduced as traffic backs up behind slower vehicles. Where the DHV is less than the values shown in Figure 15.2A, the length of two-way traffic can be extended to the limits of the project. When the DHV is greater than these values, the designer should consider installing additional crossovers to alleviate congestion. The need for additional crossovers should ultimately be determined by the review team.

2. Positive Protection. Due to the complex maneuvers required by drivers at crossovers, it may be necessary to use temporary median barriers (TMB) within the crossover; see Figure 15.4A. A TMB should also be used between crossovers if the distance between crossovers is relatively short (1 km or less). Where a project is longer than 1 km, tubular markers will generally be used to separate traffic. The decision to use TMB will be coordinated with the Construction Bureau and the Traffic Engineering Section.

3. Roadside Safety. The designer should consider the effect that directing traffic onto the opposing roadway will have on the roadside appurtenances. For example, existing trailing ends of unprotected bridge ends may require approach guardrail transitions or impact attenuators, and all guardrail terminals may need to be converted to an acceptable treatment. Relapping the guardrail for the temporary direction of travel is generally not required.

4. Crossovers. Consider the following in the design of crossovers:

   a. Tapers for lane drops should not be contiguous with the crossovers. See Section 15.3.4 for acceptable taper lengths and rates.

   b. The crossover should have a design speed that is no more than 20 km/h below the mainline design speed before the construction zone; see Section 15.3.2.

   c. The design of the crossover should accommodate the truck traffic of the roadway (e.g., surfacing widths, loads).

   d. A clear recovery area should be provided adjacent to the crossover; see Section 15.4.3.

   e. See the *MDT Detailed Drawings* for the geometric details of a typical crossover.

   f. Portable concrete median barriers and the excessive use of traffic control devices cannot compensate for a poor geometric design of a crossover.

5. Interchanges. Access to interchange ramps on freeways should be maintained even if the work space is in the lane adjacent to the ramps. If access is not practical, ramps may be closed using proper signing for alternative ramps. Early coordination with local officials having jurisdiction over the affected cross streets will be required prior to ramp closures.

   Providing access to exit and entrance ramps may require the use of additional crossovers. Sufficient deceleration and acceleration distances should be provided.

15.2.6 Work Within or Near Intersections

If the work is within or near an intersection, consider the following guidelines:

1. Keep the work space small so that traffic can move around it.

2. For temporary work, use flaggers to assign the vehicle right-of-way.

3. Complete the work in stages so the work space can be kept to a minimum.

4. Reduce traffic volumes by detouring traffic upstream from the intersection.

Where lane shifts are used through signalized intersections, the traffic signal heads and actuated detectors will need to be re-adjusted for the appropriate lane. Contact the Traffic Engineering Section for information on traffic signal designs.

15.2.7 Detours

15.2.7.1 Warrants

Detours provide the safest method of protecting traffic and workers within the construction zone. Detours allow the contractor to work unimpeded by traffic, which will typically accelerate the project completion time. On the other hand, detours will often cause substantial inconvenience and confusion to the motoring public.

1. The following presents several guidelines for where detours should be considered:

2. Detours should be considered where there is a possibility of a significant hazard to traffic and/or workers.

3. Detours should be considered where removal of traffic will substantially accelerate the project completion time.

4. Detours should be provided where construction would be impractical if traffic was maintained (e.g., total bridge reconstruction, substantially raising fill heights).

5. Detours will be required where work is done at railroad crossings. This work will generally require the closing of the roadway for 1 to 2 weeks, depending on the site.

15.2.7.2 Types

Once it has been determined that a detour is necessary, consider the following detour types:

1. Existing Routes. Detours along existing routes are generally the easiest option available to the designer. The following factors should be considered:

    a. Considerable public involvement and coordination with the affected communities will be necessary before traffic can be detoured onto an existing route.

b. Detours will generally require more travel time. Long detours may not substantially decrease traffic within the construction zone for those individuals who are unwilling to travel this extra distance.

c. The proposed detour route should have sufficient capacity to safely accommodate the additional traffic.

d. Detour traffic may significantly increase traffic delays and congestion on local roads (e.g., side streets in towns).

e. Existing traffic signals may need to be reprogrammed or temporary traffic signals installed.

f. Improvements may be required on the detour route to accommodate the increased road traffic (e.g., pavement resurfacing, increasing bridge loading capacities, roadside safety improvements).

g. Local access and approaches may still be required within the construction area.

2. Temporary Roadways. Temporary roadways (e.g., crossovers, adding lanes in the median, widening of the subgrade) are generally provided within the construction area versus detouring traffic around the area. Temporary roadways are typically constructed where:

a. a long detour would be required,
b. a heavy volume of traffic would need to be detoured,
c. substantial improvements would need to be made to the detour route,
d. increased truck volumes through towns would be unacceptable, and/or
e. the detour duration would be required for a long period of time.

Due to the limited space available, the geometric design of temporary roadways is often much more restricted. Sections 15.3 and 15.4 provide the geometric and roadside safety criteria that should be used for temporary roadways.

The installation of drainage structures associated with temporary roadways generally require a stage construction sequence. The preferred sequence of culvert installation should proceed from downstream to upstream. Sufficient additional culvert lengths are necessary to provide adequate lane widths and fill slopes during the installation.

3. Constructed Detours. Constructed detours are specially constructed temporary roadways that are built within the construction zone to bypass a bridge, railroad crossing or other similar "spot" construction area. These detours are constructed where it would be impractical to detour traffic on other existing routes.

   Design the detours using the criteria in Sections 15.3 and 15.4. However, it should be noted that they are generally more expensive, may require the purchase of construction permits, and may have adverse environmental impacts.

15.2.8 Offset Alignment

For reconstructed projects, it may be cost effective to use a new alignment which is offset and generally parallel to the existing roadways. The determination to use an offset alignment should be made at the Preliminary Field Review. Some of the factors that should be evaluated to determine if an offset alignment may be appropriate include:

1. construction costs,
2. project constructibility,
3. right-of-way availability,
4. existing development of adjacent property,
5. right-of-way costs, and
6. natural features.

Where an offset alignment is used, special concerns include the design of the connection to the existing roadway, obliteration of the existing roadway, and how to utilize material from the existing fills while maintaining traffic on the existing roadway.

15.3 GEOMETRIC DESIGN

The design criteria presented in the following sections apply to temporary crossovers on divided highways, existing roadways through construction zones and detours specifically constructed for construction projects (e.g., crossovers). It does not apply to detours over existing routes.

15.3.1 Detour Location

Recommendations for detour locations should be made at the Preliminary Field Review. Consider the following factors when determining detour locations:

1. The detour should minimize impacts to adjacent development.
2. The detour should minimize the amount and cost of utility relocations.
3. The detour should minimize environmental impacts.
4. Locate a detour which cross watercourses downstream from the construction, where practical.
5. Ensure the detour is offset a sufficient distance so as not to interfere with the construction. For bridge replacements, try to provide at least 3 m between the outside edge of the new structure (usually the wingwall) and the toe of the detour cut or fill slope.
6. Coordinate the location of detours around bridge construction sites with the Bridge Bureau.

15.3.2 Design Speed

Significant speed reductions through construction zones are undesirable and may lead to poor operating conditions. Regulatory or warning speed signs are generally ineffective with the exception, perhaps, of signs at horizontal curves. Desirably, the design speed through the work zone will be the same as that for the approaching highway and, at a minimum, should not be more than 20 km/h below the mainline design speed before construction.

The minimum acceptable detour design speed is 60 km/h. However, if the 60 km/h design speed is more than 20 km/h less than the design speed of the mainline, the reasons for its use should be documented in the Scope of Work Report. If physical constraints prohibit designing to the minimum speed, the circumstances should be documented in the Scope of Work Report along with mitigating measure incorporated to ensure the safe operation of the detour.

15.3.3 Lane/Shoulder Widths

Desirably, there will be no reduction in the cross section width through the construction zone. However, this is rarely practical. For Interstates and other divided highways, at a minimum, a 3.3 m lane width should be maintained through the construction zone and, preferably, with a 0.6 m or wider right and left shoulder. Under restricted conditions, a 3.0 m wide lane may be used if there is an alternative route provided for wide vehicles. Crossovers on divided highways must provide a 3.6 m minimum width. For other highways, the lane and shoulder width selection should be 3.3 m or wider. The designer should minimize the use of width reductions. Where necessary, Figure 15.3A presents the minimum taper rates that should be used when reducing widths.

15.3.4 Lane Closures/Other Transitions

The designer should ensure that the taper rate conforms to the MUTCD criteria. These taper rates are shown in Figure 15.3A. Figures 15.3B and 15.3C present and illustrate, respectively, the minimum taper lengths for various taper applications in construction zones (e.g., lane closures, lane shifts).

15.3.5 Sight Distance

Changes in the geometric design of the existing highway are often necessary through construction zones (e.g., lane shifts, detours). Therefore, the available sight distance to the approaching motorist is especially important. Unfortunately, the location of many design features often are dictated by construction operations. However, some elements may have an optional location. For example, when lane closures and other transitions are specially designed, these should be located so that the approaching driver has at least the minimum stopping sight distance available to the closure or transition. The minimum stopping sight distances are presented in Section 8.6 and will be based on the construction zone design speed.

Design Speed (km/h)	Taper Rate
30	10:1
40	15:1
50	20:1
60	25:1
70	45:1
80	50:1
90	55:1
100	60:1
110	70:1
120	75:1

TAPER RATES FOR LANE REDUCTIONS

Figure 15.3A

TYPE OF TAPER	TAPER LENGTH
UPSTREAM TAPERS	
Merging Taper	L Minimum
Shifting Taper	2 L Minimum
Shoulder Taper	a L Minimum
Two-way Traffic Taper	30 m Maximum
DOWNSTREAM TAPERS (Optional)	30 m per lane

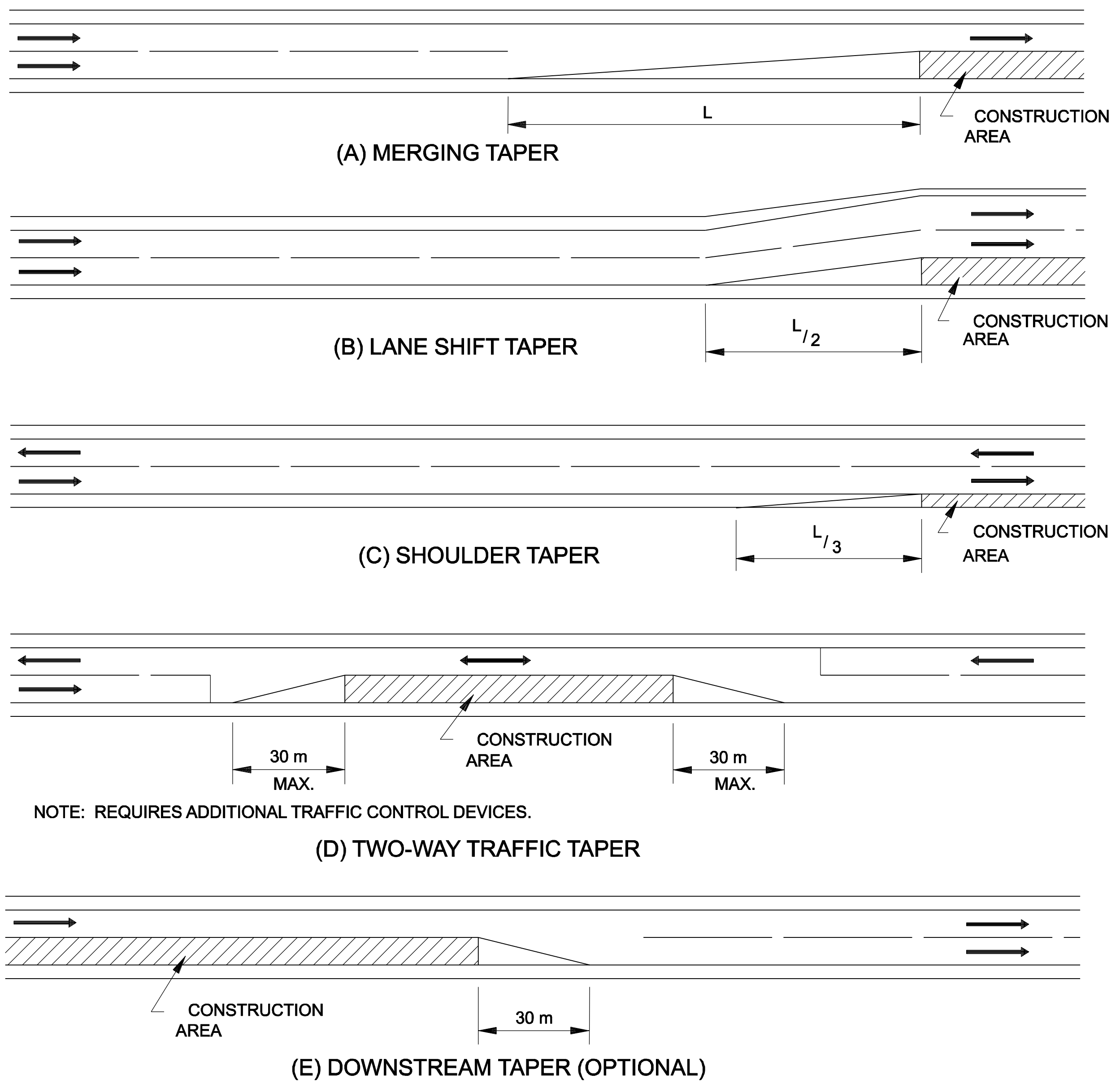
Notes:

1. Length "L" determined from Figure 15.3A.

2. Figure 15.3C illustrates the various taper types.

TAPER LENGTH CRITERIA FOR CONSTRUCTION ZONES

Figure 15.3B



Length "L" determined from Figure 15.3A.

TAPER LENGTH CRITERIA FOR CONSTRUCTION ZONES
(Application)

Figure 15.3C

15.3.6 Horizontal Curvature

15.3.6.1 Minimum Radii/Superelevation

The minimum radii and superelevation of any horizontal curves will be determined using the selected design speed for the construction zone (Section 15.3.2). In construction zones, the AASHTO Method 2 for distributing superelevation and side friction may be used to determine the radius and superelevation rate of any curve. In this method, superelevation is introduced only after the maximum allowable side friction has been used. This results in eliminating superelevation on flatter curves and reducing the rate of superelevation on the majority of other curves.

Typically, the PTW is widened for the detour connection using the same cross slope as exists on the PTW. Figure 15.3D provides the minimum horizontal curve radii for retaining normal crown, based on AASHTO Method 2, for detour connections to tangent PTW sections. Detour connections to superelevated PTW sections should be accomplished with horizontal curves requiring the same superelevation, based on AASHTO Method 2, as the in-place superelevation of the PTW. As discussed in Section 9.3.8, the minimum distance between the PT and PC of reverse superelevated curves will be that needed to meet the superelevation runoff length requirements for the two curves.

Figure 15.3F illustrates a typical three-horizontal curve alignment for a minimum-length, 80 km/h constructed detour providing approximately a 15 m offset. The following factors should be considered when establishing a detour alignment:

1. 1Selecting radii requiring a normal crown (NC) for curves exiting/entering tangent PTW accommodates vehicles turning onto/off the detour on the retained adverse crown of the PTW.

2. Selecting radii requiring NC allows the PC and PT of successive curves to be coincident and eliminates the need for superelevation transition lengths.

3. If selection of radii requiring superelevation is necessary, ensure that the proper transition lengths as shown in Figure 15.3E are provided as illustrated in Figure 15.3G.

4. Typical offsets between the edge of a new structure and the edge of a detour shoulder is 3.0 m.

5. Provide a 1.2 m radius nose at the gore.

Design Speed, V (km/h)	f_{max} (Open-Roadway Conditions)	Minimum Radii, R_{min} (for Normal Section) (e = -2%) (m)	Minimum Radii, R_{min} (e = 8%) (m)
30	.17	50	30
40	.17	85	55
50	.16	145	85
60	.15	220	125
70	.14	325	180
80	.14	420	230
90	.13	580	305
100	.12	780	395
110	.11	1060	550

Notes:

1. *Curve Radii. Radii are calculated from the following equation:*

   $$R = \frac{V^2}{127(e = f)}$$ *;values for design have been rounded up to the next highest 5 m increment.*

2. Normal Section. If the normal section is maintained through the horizontal curve, the superelevation rate is -.02 assuming a typical cross slope of 2%. Therefore, the R_{min} column with e = -2% presents the minimum radii which can be used and retain the normal section through the horizontal curve.

3. Other Radii. For proposed radii or superelevation rates intermediate between the table values, the equation in Note #1 may be used to determine the proper curvature layout. For example, if the construction zone design speed is 100 km/h and the proposed curve radius is 500 m, then the superelevation rate is:

$$e = \frac{V^2}{127R} - f$$

$$e = \frac{(100)^2}{(127)(500)} - 0.12$$

$e = +4.0\%$ (Round the calculated superelevation rate to the next highest hundredth).

MINIMUM RADII FOR HORIZONTAL CURVES
(Construction Zones)
Figure 15.3D

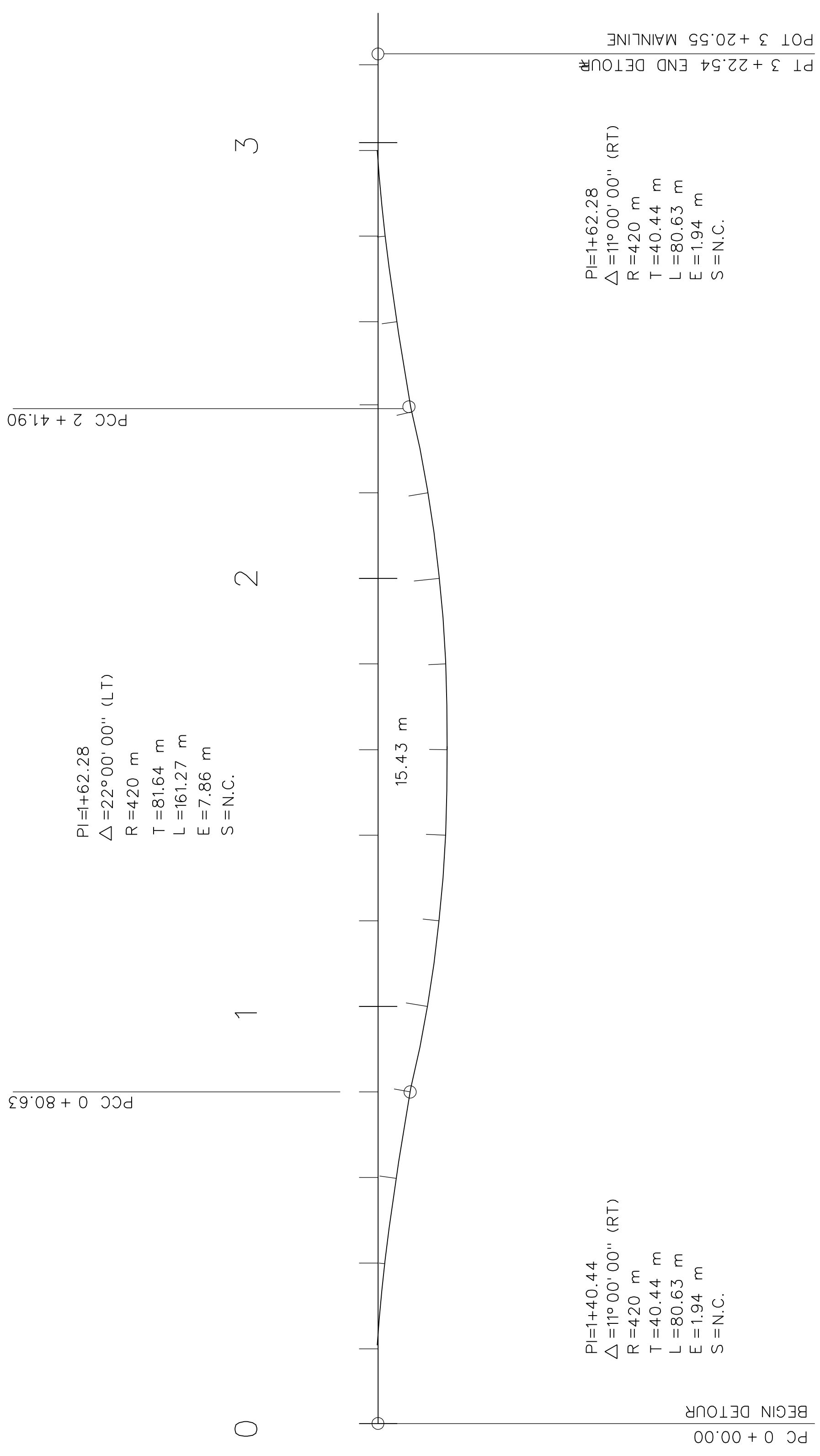
Design Speed (km/h)	RS	Superelevation Rate	Transition Length	
			L (m)	TR (m)
50	150	2.0%	15	15.00
		3.0%	20	13.33
		4.0%	25	12.50
		5.0%	30	12.00
		6.0%	35	11.67
		7.0%	40	11.43
		8.0%	45	11.25
60	167	2.0%	15	15.00
		3.0%	20	13.33
		4.0%	25	12.50
		5.0%	35	14.00
		6.0%	40	13.33
		7.0%	45	12.86
		8.0%	50	12.50
70	182	2.0%	15	15.00
		3.0%	20	13.33
		4.0%	30	15.00
		5.0%	35	14.00
		6.0%	40	13.33
		7.0%	50	14.29
		8.0%	55	13.75
≥ 80	200	2.0%	15	15.00
		3.0%	25	16.67
		4.0%	30	15.00
		5.0%	40	16.00
		6.0%	45	15.00
		7.0%	55	15.71
		8.0%	60	15.00

Key :

RS = Reciprocal of maximum relative longitudinal slope
L = Superelevation runoff length, m
TR = Tangent runout length, m

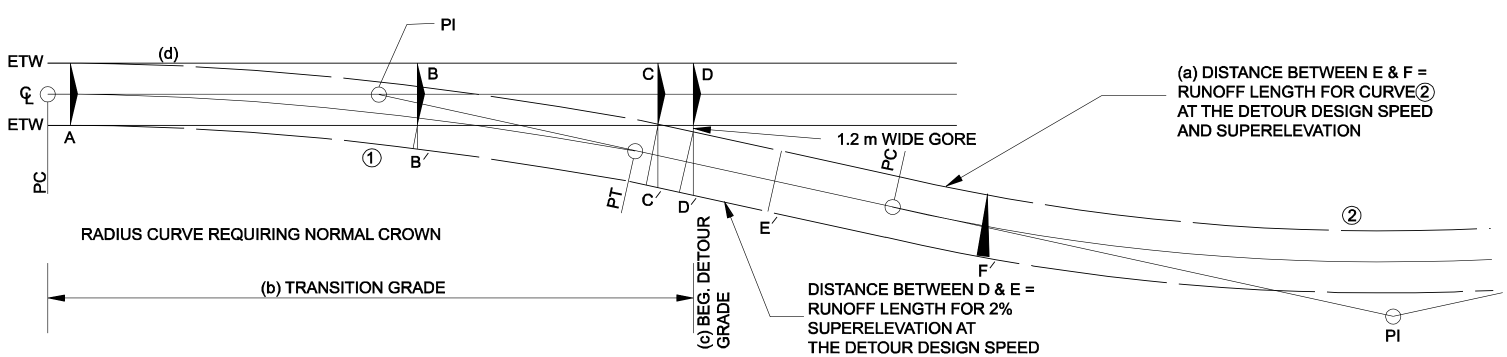
MINIMUM SUPERELEVATION TRANSITION LENGTHS
(2-Lane Detours)

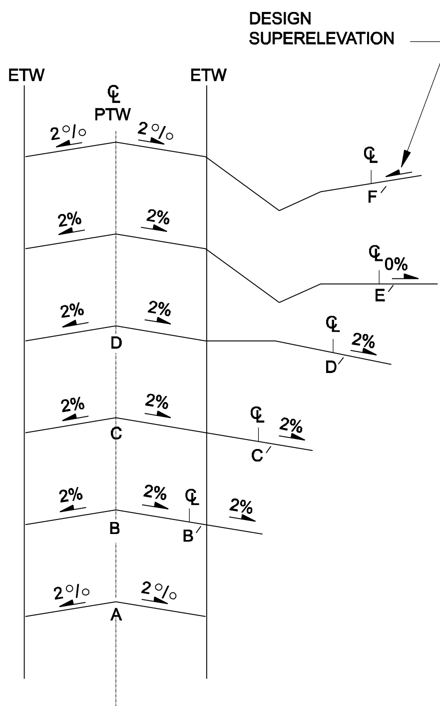
Figure 15.3E



TYPICAL DETOUR ALIGNMENT
(Maintaining Normal Section)
(Design Speed: 80 km/h)

Figure 15.3F





Notes:

(a) This applies if Curve ② is superelevated. If Curve ② is flat enough to retain the normal crown, the PT of Curve ① and PC of Curve ② can be coincident. Transitioning the 2% cross slope at Section D' to normal crown can then be accomplished within Curve ②.

(b) Throughout the transition grade, detour centerline elevations are computed by multiplying the offset distance and the cross slope between the centerlines. This distance is then subtracted from the mainline centerline elevation.

(c) Independent detour grade begins at the point of full separation between mainline and detour (Section D').

(d) Detour connections to a curved previous traveled way (PTW) alignment should be accomplished with a horizontal curve requiring the same superelevation, based on Figure 15.3D, as the in-place superelevation of the PTW.

HORIZONTAL CURVES FOR DETOURS
(With Superelevation)

Figure 15.3G

15.3.6.2 Transition Lengths

Section 9.3.5 presents MDT criteria for superelevation transition lengths for permanent construction projects. Desirably, these lengths will be provided for detours in construction zones. At a minimum, the runoff lengths in Figure 15.3E may be used. These lengths have been calculated using steeper relative longitudinal gradients than those in Section 9.3.5 for V > 80 km/h, and the use of minimum superelevation runoff lengths does not apply to Figure 15.3E. Note that, as with permanent construction, the tangent runout (TR) lengths must be added to the superelevation runoff lengths to determine the total transition length.

15.3.7 Vertical Alignment

A transition grade should be used for the detour alignment from the beginning/end of the detour to the gore. An independent grade should be designed between the gores.

Throughout the transition grade area, detour centerline elevations are computed by multiplying the offset distance and the cross slope between the PTW centerline and detour centerline. This distance is then subtracted from the PTW centerline elevation to produce the detour centerline elevation.

Ensure detour grade provides minimum cover for all culvert options to accommodate the waterway opening or elevation required for placement of temporary bridge.

Vertical curve criteria presented in Chapter Ten is also applicable to detours.

15.3.8 Surfacing

Determine the type of surfacing to be used on the detour at the Preliminary Field Review and review this decision at the Plan-in-Hand. All detours for Interstate projects will be paved. Detours for projects on other routes may have paved, oiled or gravel surfaces. Factors that influence the type of surfacing utilized for these detours include:

1. the ADT on the route (routes with higher ADT's will require more durable surfacing),
2. the length of time the detour will be in use, and
3. the maintenance that would be required for the various types of surfacing. The ADT will also affect the level of maintenance.

See Figure 15.3H for general guidance as to the type of surfacing for detours. The surfacing type should be determined prior to Scope of Work Report.

15.3.9 Cut and Fill Slopes

Wherever practical, construct detour cut and fill slopes according to the design criteria in Chapter Twelve. The use of 3:1 fill slopes is acceptable where a sufficient clear zone is available at the bottom of the slope. The use of steeper fill slopes may require the installation of barriers.

Although detours rarely involve excavation (cut), 3:1 cut slopes are generally acceptable in place of the 5:1 and 4:1 slopes described in Chapter Twelve. The use of slopes steeper than 3:1 for cut depths less than 3 m should be reviewed at the Plan-in-Hand.

The anticipated traffic volumes, design speed of the detour and the length of time the detour will be in place should be weighed in determining cut and fill slopes.

15.3.10 Temporary Pavement Markings

The designer is responsible for determining the quantities of temporary pavement markings. Calculate the quantities of each 2-lane kilometer for each pavement marking application. Additionally, temporary pavement markings may be required after:

1. milling operations,
2. between each pavement lift, and
3. after seal and cover operations.

They may also be required on existing pavements and on top of the seal and cover. Chapter Five presents the procedures for estimating quantities.

Current ADT	Duration of Detour Operation			
	< 5 Days	5 - 30 Days	31 Days - 3 Months	> 3 Months
< 500	gravel	gravel	prime	prime
500 - 1499	gravel	prime	prime	PMS
1500 - 6000	prime	prime	PMS	PMS
> 6000	prime	PMS	PMS	PMS

GUIDELINES FOR SELECTION OF DETOUR SURFACING

Figure 15.3H

15.4 ROADSIDE SAFETY

As drivers traverse construction zones, they are often exposed to numerous hazards including restrictive geometrics, construction equipment and opposing traffic. Elimination of these hazards is often impractical. Regardless, consideration must be given to reducing the exposure of motorists to hazards.

15.4.1 Positive Protection

During the planning and design of a project, give careful consideration to traffic control plan alternatives that do not require the use of temporary barriers. This can often be accomplished by using detours, constructing temporary roadways, minimizing exposure time, and maximizing the separation between traffic and workers. Even with proper project planning and design, there will still be many instances where positive protection should be considered.

Because each site should be designed individually, MDT has not developed specific warrants for providing positive protection in construction zones. The Construction Bureau and field construction personnel will make the determination whether to provide positive protection in construction zones. The use of positive protection should be discussed at the Plan-In-Hand. The following provides a list of factors that should be considered:

1. duration of construction activity,
2. traffic volumes (including seasonal fluctuations),
3. nature of hazard,
4. design speed,
5. highway functional class,
6. length of hazard,
7. proximity between traffic and construction workers,
8. proximity between traffic and construction equipment,
9. adverse geometrics which may increase the likelihood of run-off-the-road vehicles,
10. two-way traffic on one roadway of a divided highway,
11. transition areas at crossovers, and/or
12. lane closures or lane transitions.

15.4.2 Appurtenance Types

The designer's first objective should be to provide a design that eliminates the need for temporary barriers. However, this is often not practical. In addition to Chapter Fourteen and the *MDT Detailed Drawings*, the following provides general information on the roadside safety appurtenances used by the Department through construction zones:

1. Guardrail/Median Barrier. For most construction projects, the installation of a new temporary guardrail/median barrier is usually not cost effective due to the short project life. Where used, temporary guardrail/median barrier installations must meet the permanent installation criteria set forth in Chapter Fourteen and the MDT Detailed Drawings, except where modified in Section 15.4.4.

2. Temporary Median Barrier. The most common type of portable barrier is a temporary median barrier (TMB). A TMB provides the greatest protection from the construction zone and between two-way traffic, but it is also the least forgiving to the driver. The primary functions of the TMB in construction zones are:

   a. to keep traffic from entering work areas (e.g., excavations, material storage sites);

   b. to protect workers and pedestrians;

   c. to separate two-way traffic;

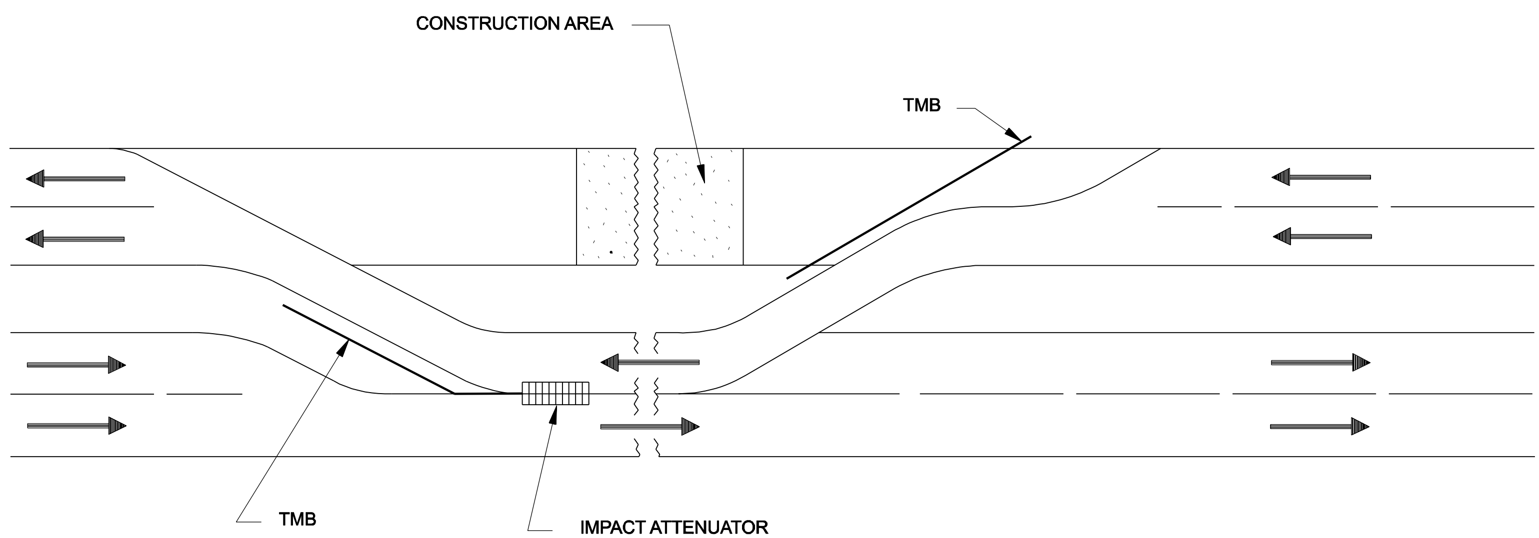
   d. to shield obstacles and edges; and

   e. to protect construction such as falsework for bridges and other exposed objects.

   Figure 15.4A illustrates the suggested locations for the TMB at crossovers to eliminate head-on accidents. For other locations, the decision on where to use a TMB in construction zones will be determined on a site-by-site basis.

   Another type of barrier that may be used is a water-filled lightweight, polyethylene plastic shell. The shells are supplemented by an internal steel framework to provide additional rigidity during handling and impacts. There is also a cable at the top connecting the joints between barrier segments. Upon impact, these devices may deflect up to 3.6 m. They may be used where high portability is desired and in congested urban work sites.

3. End Treatments. Even when protected or otherwise mitigated, the ends are the most hazardous element of any barrier system. Therefore, any unprotected terminal ends for guardrail or the TMB should be located as far as practical from the roadway or be protected with an appropriate end treatment. This includes breaks in the barrier for crossovers and/or contractor access openings.



If the crossover distance is less than 1 km, then TMB should be used throughout the crossover.

TEMPORARY MEDIAN BARRIER LOCATIONS
(Crossovers)

Figure 15.4A

The construction zone QuadGuardCZ is the preferred end treatment to protect the blunt end of the TMB. Although a construction zone TRACC is not available at this time, the Department anticipates that one will be available in the near future. These end treatments should also be used where space does not allow the use of sand barrels at point obstacles (e.g., bridge piers). Where space is available, the CAT and Brakemaster should also be considered.

Chapter Fourteen provides information on other end treatments used by the Department. Provide the safest end treatment consistent with cost effectiveness and geometric considerations.

15.4.3 Design/Layout

In general, when designing and laying out temporary roadside safety appurtenances in construction zones, use the criteria set forth in Chapter Fourteen. However, due to the limited time exposure, it may not always be cost effective to meet the permanent installation criteria. The following provides several alternatives the designer may use in designing and laying out temporary roadside safety appurtenances:

1. Clear Zones. Applying the clear zone distances for new construction/reconstruction, as presented in Chapter Fourteen, to construction zones is often impractical. MDT has developed revised distances for clear zones through construction zones, which are presented in Figure 15.4B. Due to the hazardous conditions which typically exist in construction zones, the designer still must use considerable judgment when applying these clear zone distances. Note that it is not necessary to adjust the construction clear zones in Figure 15.4B for horizontal curvature.
2. Length of Need. As with new installations, provide a sufficient distance of a full-strength barrier prior to the hazard to minimize the potential for a vehicle to run behind the barrier and impact the hazard. For temporary layouts, determine the length of need by using an angle of 15E from the back of the hazard or from the clear zone distance off the travelway.
3. Shoulder Widening. When a temporary barrier is placed next to the shoulder, it is not necessary to provide the extra 0.6 m shoulder widening.
4. Flare Rates. Desirably, the TMB terminus should be flared away from the traveled way to a point outside of the clear zone. Figure 15.4C presents the desirable flare rates for the TMB based on the design speed in construction zones. The designer should provide these flare rates unless under extenuating circumstances it is impractical to do so (e.g., stop conditions, driveways, intersections).

Detour Design Speed	ADT	Fill Slopes			
		6:1 or Flatter	5:1	4:1	3:1
60 km/h or less	< 750 750-1499 1500-6000 > 6000	1.0 m 1.5 m 2.0 m 2.0 m	1.5 m 2.0 m 2.0 m 2.5 m	1.5 m 2.0 m 2.5 m 3.0 m	See Procedure in Section 14.2.3.
70 km/h	< 750 750-1499 1500-6000 > 6000	1.5 m 2.0 m 2.0 m 2.5 m	1.5 m 2.0 m 2.5 m 3.0 m	2.0 m 2.5 m 3.0 m 3.5 m	
80 km/h	< 750 750-1499 1500-6000 > 6000	1.5 m 2.0 m 2.5 m 3.0 m	2.0 m 2.5 m 3.0 m 3.5 m	2.0 m 3.0 m 4.0 m 4.0 m	
90 km/h	< 750 750-1499 1500-6000 > 6000	2.0 m 2.5 m 3.0 m 3.5 m	2.5 m 3.0 m 4.0 m 4.5 m	3.0 m 4.0 m 5.0 m 5.0 m	
100 km/h	< 750 750-1499 1500-6000 > 6000	2.5 m 3.0 m 4.0 m 4.5 m	3.0 m 4.0 m 5.0 m 5.5 m	4.0 m 5.0 m 6.0 m 7.0 m	
110 km/h	< 750 750-1499 1500-6000 > 6000	3.0 m 3.5 m 4.0 m 4.5 m	3.0 m 4.0 m 5.0 m 6.0 m	4.0 m 5.5 m 6.5 m 7.0 m	

Notes:

1. *All distances are measured from the edge of the traveled way (ETW).*

2. *For clear zones, the ADT will be the total current ADT for both two-way roadways and one-way roadways.*

3. *See Section 14.2.4 for application of clear zones in cut sections.*

CLEAR ZONE DISTANCES (m)
(Construction Zones)

Figure 15.4B

Detour Design Speed	Flare Rates
70 km/h or less	9 to 1
80 km/h	11 to 1
90 km/h or greater	13 to 1

FLARE RATES FOR TEMPORARY MEDIAN BARRIER

Figure 15.4C